J J. Mater. Environ. Sci. 7 (10) (2016) 3614-3622 *Frenda*
ISSN : 2028-2508
CODEN: JMESCN **CIAT2015**

Earthen architecture in the agri-cultural heritage system: sustainable development, restoration and continuity of tradition

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Abstract
Humans started to settle in the territory and making architecture since they began to practice agriculture. They took advantage from the knowledge of the territory (winds orientation, sun exposure, presence of vegetation, water availability, etc.) to design their houses, the settlements and the agricultural landscape. The agri-cultural heritage system reflects the complexity of relationships that people establish both among themselves and with the physical and geographical environment and its own vernacular architecture, frequently built using techniques of earth construction. Therefore earthen vernacular buildings are a fundamental and valuable part of the world's built heritage, a non-monumental, non-formal, non-architect designed architecture that express the ability of man to take charge of shaping his living environment by the practices of self-production of materials, self-construction and self-finishing: it represent a form of "living heritage" which passes intangible cultural traditions of the local community from generation to generation, including the construction techniques useful to protect and restore this inheritance. Comparing efforts and ongoing experiences in different countries -taking into account the diversity in cultural, geographical and heritage aspects- allows to clarify the state of the art of this field of research, to identify weaknesses, strengths, sharable methodologies. China is the holder of a vast inheritance of earthen structures similar in many aspects to others located in various parts of the globe: we can compare, for example, the hypogea cave dwellings in Matmata (Tunisia) (Figure 1) to the yáodòng shelters dug in the Loess Plateau (Figure 2) or the foggara structures in North Africa (Libya and Algeria) to the Karez water system in Turfan (Xinjiang, China). China is undertaking a sustainable development with a holistic approach that takes into account the environmental, cultural, social, technological and economic aspects, supporting several development projects by applying the principles of dynamic conservation, involving residents to actively participate in order to ensure the transfer of knowledge and know-how needed to preserve the agri-cultural heritage system.

Keywords: Earthen architecture, vernacular constructive systems, earthen heritage restoration, sustainable development, yáodòng cave-dwellings

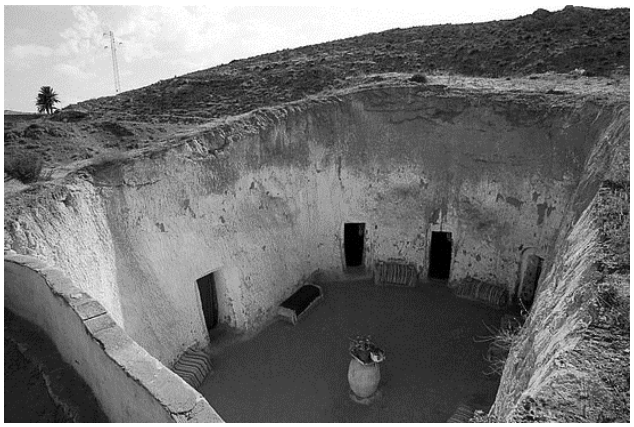
Figure 1: Hypogea cave dwelling (Matmata, Tunisia)


Figure 2: Yáodòng cave dwelling (Lintong, PRC)

1. Introduction

Inhabit the Earth is the fundamental link that humankind, since its appearance, has with the world and from the earth -in the earth- mankind has always found his livelihood.

Aware of this important link between humankind and Earth, is necessary rethink about the human settlements that in their own design must return to confront themselves with the natural data, finding in the geographical elements the reason of their shapes.

Earthen architecture is the result of thousands of years' experience of a traditional technology at the same time popular and erudite. It takes on a key role in the construction of the territory in an intimate relationship with nature: in this architecture, the natural element becomes a built fact.

It is also the embodiment of the cultural identity of the humankind and every efforts must be conducted to protect this valuable inheritance.

According to the Council of Europe Framework Convention on the Value of Cultural Heritage for Society (Faro, 27 October 2005):

> «*Cultural heritage is a group of resources inherited from the past which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. It includes all aspects of the environment resulting from the interaction between people and places through time*».

Over the last decades, the threat of globalisation and urbanisation (especially in the BRIC countries) has made it necessary to urgently find solutions for the protection of the cultural assets that constitute our world's inheritance, considering its own social and economic value.

In these contexts earthen architecture plays a key role both in terms of conservation and sustainable development.

Analyze and protect earthen architectural heritage, first of all, must be a moral obligation and it also represents a chance to face the development in a sustainable way.

Through the knowledge we can properly preserve the value of traditional buildings giving it a new significance while offering affordable housing for as many people as possible and face the problem of energy conservation both before and after the building process (less consumption of energy for the preparation of materials to be used in the construction and lower consumption of energy for indoor heating and cooling).

It is not easy to preserve the cultural heritage in living contexts densely-populated and fast-developing, and for this reason the conservation of society's cultural capital is therefore a matter of urgent concern for all who are concerned with human development.

Nowadays we must connect the conservation goals with the objective of smart, inclusive and sustainable growth.

Local communities must be encouraged to use their local cultural assets as a springboard through a process whereby local actors are encouraged to assume an active stewardship over the heritage and are empowered to develop that heritage in a responsible, profitable and sustainable manner.

In this sense, UNESCO's LEAP (Local Effort And Preservation) program in Asia-Pacific region aims to complement and extend efforts at heritage conservation by moving it beyond the exclusive sphere of a high technology and elite specialisation to become the concern (indeed the responsibility) of every man, woman and child. In other words the heritage conservation should be transformed into a grass-roots movement which will return the heritage to the communities which created it and which rely on this heritage as the foundation for their future development.

Through LEAP, communities are given the opportunity to share the economic benefits of enhanced conservation, while maintaining their own social and cultural traditions.

2. Learning from vernacular: Chinese earthen architecture from tradition to innovation

Human settlements and habitat (both in rural and urban areas) are the results of the cultural diversity and expression of tangible and intangible inheritance.

Built to meet needs, earthen architecture connects architecture, culture and society, becoming vehicle of transmission of tradition adjusting itself to the changing social needs. "Learning from vernacular" (Frey, 2010) means to look back to the tradition, finding in it the best way to drive the innovation.

In contemporary world it is needed to create a sharing of information among the countries regarding scientific study of the earth material and of the building techniques with the purpose to establish a solid assessment of its potential in the future.

Examining how in other contexts the problems related to the earthen architecture will be solved (seeking common points of contact but at the same time taking into account the peculiarities of each specific case), can certainly lead us to find shareable methodologies.
Specifically, a comparison with the Chinese context is interesting for two reasons: 1) part of the Chinese earthen architectural heritage has technical-executive and typological analogies with that North Africa; 2) seeing how the Chinese developing context will solve the housing problem through the restoration and modernization of the earthen architecture, could suggest solutions and provide ideas to be used in North Africa or elsewhere.

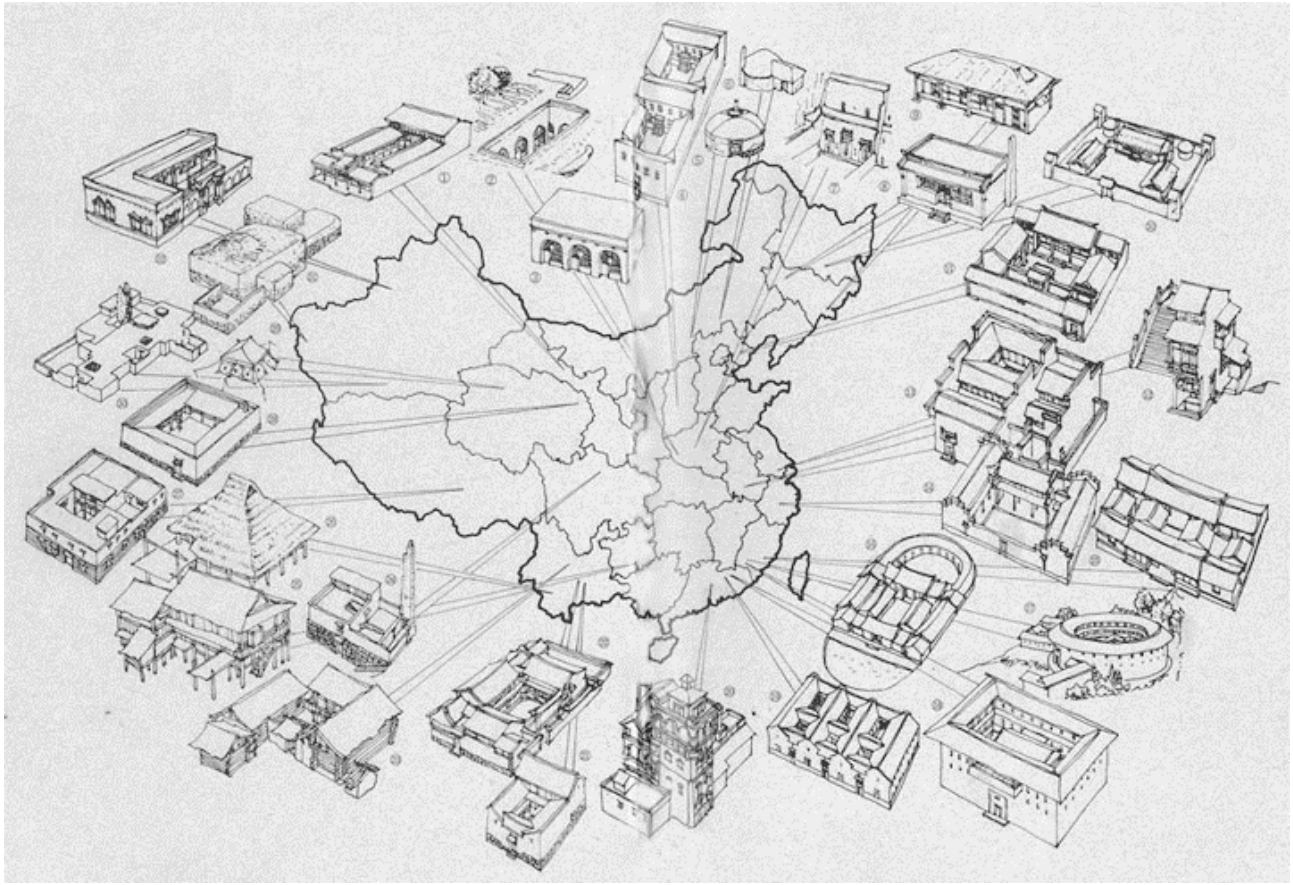

Figure 3: Map of Vernacular architecture in China (by MIT Building Technology)

2.1. Background
Techniques of earth construction in China have a long history being used to build villages, defence ramparts, caves and semi-caves dwellings since the Neolithic Age.
Nowadays China counts 47 properties inscribed on the World Heritage List and most of these sites are valuable material evidences of the use of earthen techniques through the centuries.
Noteworthy is the recent nomination, in 2014, of the serial and transnational site of "*Silk Roads: the Routes Network of Chang'an-Tianshan Corridor*".
Meanwhile since 2008 the site "*Chinese Section of the Silk Road: Land routes in Henan Province, Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, and Xinjiang Uygur Autonomous Region; Sea Routes in Ningbo City, Zhejiang Province and Quanzhou City, Fujian Province - from Western-Han Dynasty to Qing Dynasty* " is listed in the Tentative List.
Silk Roads sites include in itself many earthen cultural heritage and represents an important opportunity for the recognition and the study of this inheritance.
It is important to be noticed that in January 1989 the Getty Conservation Institute agreed to collaborate with the State Bureau of Cultural Relics of the People's Republic of China on the conservation of two ancient Buddhist sites: the Mogao Grottoes, a World Heritage Site near Dunhuang in the Gobi Desert (northwest

China), and the Yungang Grottoes, near Datong, a coal-mining centre some 320 kilometres west of Beijing. This cooperation represents the first attempt to bring together Chinese and Western scholars on the subject of grotto sites conservation (Agnew-Neville, 1997, 2010).

In addition to these sites (already designated or with the potential to be designated as World Cultural Heritage Sites), there is an important part of the Chinese earthen cultural heritage (represented by the vernacular architecture in rural villages) at high risk.

In contemporary China many rural villages (that still support agriculture production and accommodate almost half of the Chinese population) are under threat from the modernization and globalization processes.

China is pushing ahead with a sweeping plan to move 250 million rural residents into newly constructed towns and cities over the next dozen years, an attempt that is reshaping a nation that for millennia has been defined by its rural life (Johnson, 2013).

Rural villages are in danger not only because the urban sprawl, the overbuilding, the general problem of environmental degradation, the under-development and the migration of young people from the rural areas to large cities, but also because people assume that earthen structures are unimportant or in some way more primitive than buildings constructed with other masonry materials and for these reasons inevitably in decline and not conservable in some way.

The history of earthen architecture has never been looked at. As a consequence, earthen architecture does not have a history. It is perceived as unimportant.

This means that conservation approaches have to face the problem of lack in research: except for a few documents, in technical publications no reference to earthen architecture can be found.

Therefore, in this field, fundamental must be scientific studies, pragmatic testing and development of methods for conserving sites and structures, and, above all preserving traditional folk knowledge that could inform current conservation practice.

The Chinese government has took cognizance of the importance of the vernacular architecture in the agri-cultural system and since 2003 has designated 276 sites as “Chinese Historic and Cultural Cities and Villages” (中国历史文化名村 “Zhōngguó lìshǐ wénhuà míng cūn”).

In addition to this list a joint inventory of a plenty of “Traditional Villages” was undertaken by the Ministry of Housing and Urban-Rural Development, the Ministry of Culture, the Ministry of Finance and the State Administration of Cultural Heritage (by the end of 2014, a total of 2.555 "Traditional Villages" have been designated).

A “Traditional Village” is defined as a village with a long history and a rich tradition that is significant in terms of its history, culture, science, art, society and the economy and that is worthy of conservation. Villages that have only recently been established can also be listed as “Traditional Villages” provided they have maintained past traditions.

In December 2013, President Xi Jinping in his speech has referred to the "conservation of historic rural landscapes" and said that the traditional villages are part of a "memorable nostalgia".

To preserve the traditional villages is therefore necessary to raise the living standards of the rural areas. To this end, Premier Li Keqiang issued instructions that incites inclusion of farmers in the preservation process. The wishes and needs of farmers must be respected as well as it is necessary to preserve the character of the villages in one's own traditional culture (Luo Deyin, 2015).

Promote a sustainable development by applying the principles of dynamic conservation seems to be the way to reconcile the relationship between man and nature: the participation in the construction, rehabilitation and preservation processes of people from different generations and skills (and not only experts) encourages the transfers of knowledge and know-how and contributes to improve social outcomes. In this direction the Chinese government is carrying on the “Loess Plateau Watershed Rehabilitation Project“. This project is based on the principles of dynamic conservation and is a test pattern of development of agricultural landscape compatible with the need of the conservation of cultural heritage that takes into account the preservation of local traditions (Frenda, 2015).

2.2. Traditional earthen architectural heritage: the yáodòng cave-dwellings

In northern China, in the Loess Plateau, the peculiar characteristics of the *Loess* soil (a porous and waterproof soil, consisting primarily of fine quartz, structurally uniform, which can be easily dug creating stable structures warding off subsidence and collapses) have permitted the development of cave-dwellings known as *yáodòng*.

Yáodòngs are built and designed depending on the landscape, and in the landscape they have their material substance.
In flat areas we can find the "sunken courtyard-type" (Figure 4) consisting in an underground structure that develops from ground level down, deep down. In this quadrangular patio dug vertically into the ground, the residential rooms have their opening, built continuing the excavation in the horizontal direction.
Along the hills we can find the "cliffside-type" (Figure 5). In this case the yáodòng is built over the ground level by digging the ground in the horizontal direction of the hills' walls. Often this solution founds settlements in tiered structure.
In addition to these two basic types a further typological solution can be found, the "vaulted cave dwellings – type" or "stand-alone" type (Figure 6) , a hybrid that is the result of an "additive act". In this *yáodòng* type, bricks or stones are used to build the typical arch structure subsequently covered on the outside from the ground in order to obtain a thick flat roof.
This type could be originated by the constant search for better solutions or simply by a choice to switch from a dug architecture to a built architecture, from hidden to visible, from the underground to the surface. It is also possible that this typology is the result of an adjustment to the geological instability of the ground.

Figure 4: "sunken courtyard" Yáodòng (Lintong, PRC)

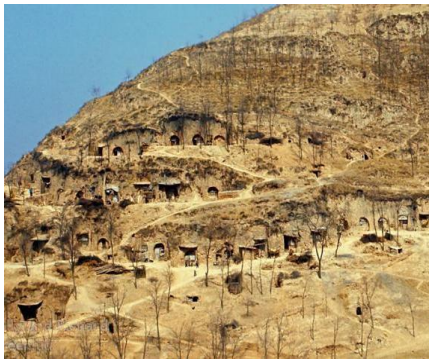

Figure 5: "cliffside-type" Yáodòng (Yan'an, PRC)

Figure 6: "stand alone-type" Yáodòng (Zhaidan, PRC)

2.3. Innovative earthen architecture: the new generation of yáodòng cave-dwellings
Influenced by the principles of inclusion, innovation and social responsibility, in recent years we have witnessed to the emergence of a new generation of *yáodòng* that in the respect local traditions offer modern living standards in low-cost housing (Figures 7, 8).
Starting with a pilot project of 85 houses in Zaoyuan village (1996-2001) built by families using self-help construction methods, the project has now seen an exponential growth of this new type of housing.
This project established a new model house for the rural population that is connected to local and traditional roots, but that meets changing social and economic circumstances and expectations, improving and solving the problems of the traditional typology. The following solutions have been adopted:
-a two-storey construction rather than single-storey in order to increase the amount of available functional space;
-the use of innovative solar energy systems and natural ventilation methods in order reduce to minimum the energy consumption for heating, ventilation and air conditioning;
-the south orientation of the arched openings in conjunction with the use of earth sheltering building methods on top of the traditional arch construction in order to increase the thermal stability reducing the need for internal heating.
The earth sheltering nature of the design means that even at external temperatures of -20°C, the internal temperature can be maintained at 10°C, using only the traditional *kang* (stone bed linked to an internal stove). Old style yáodòng dwellings consume 15 kg of coal per m^2 for heating; new concrete houses require 25 kg, whilst new yáodòng dwellings require 0.5 kg.
The project has resulted in CO_2 savings and minimisation of pollution from the construction process through the use of existing terrain and minimal construction materials.

Lastly the new *yáodòng* are built into hill terraces on land that is infertile or hard to farm, thus maintaining the amount of land available for agriculture.

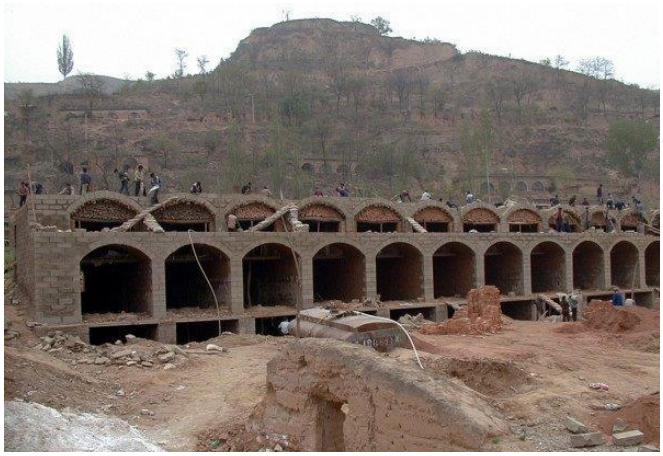

Figure 7: The New Generation of Yaodong Cave Dwelling under construction

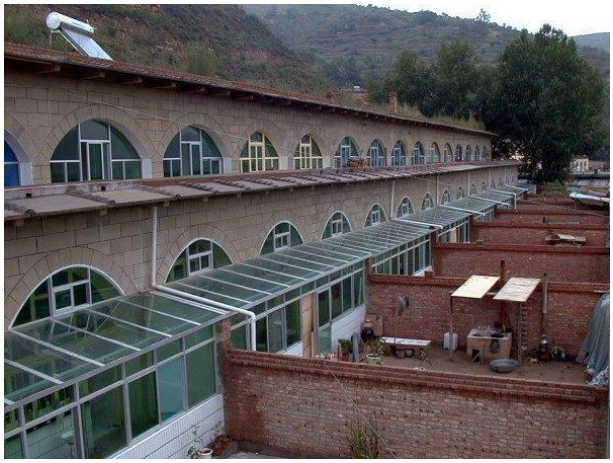

Figure 8: The New Generation of Yaodong Cave Dwelling

2.4 Development of the earthen settlement in Luochuan County between restoration and renovation

The north-western part of the People's Republic of China has become, with the 2012-2020 urban development planning, the main area of future infrastructural development of the country. Historically lagged behind the development of coastal areas, this part of the country is growing at a rapid pace, with the support of the objectives of national planning.

In Shaanxi Province, historic heart of the Country, a plenty of rural villages (made up of earthen architectural heritage and inserted in the agri-cultural system) are developing.

Just in this part of China, which gave birth to all the national traditions and guards most of the ancient monuments of the country, is taking place a cultural debate about the protection of its past, returned to prominence after the great discovery of the famous Terracotta Army which inserted the province in the international tourist circuit, making it a must for travellers around the world.

These development programs consider the cultural heritage as a sector of activities which provides jobs and generates growth and are focused in the spill-over social and economic effects of cultural heritage in other fields, such as agriculture, regional development, environment, science and education, tourism, technology, innovation, social cohesion, intercultural dialogue, etc.

The overall planning of tourism development (2015-2030) of the old town of Yao Chang Gu Zhai, in Luochuan County, (led by Shao Zhenyu, president of Xi'an Tourism Planning Design Institute and Director of Xi'an Center of Cultural Industry Research) is oriented to use the history and old traditions of the site for future prospects. According to the national and local law and regulations, the project protects the value of built vernacular earthen heritage taking into account the spirit of the place (Figures 9, 10, 11).

In order to permit to the people to continue living in the site (taking consideration of the changing social needs) some rehabilitation work are undertaken to accommodate the buildings to today's residential needs (for example through renewal of electrical or sanitary systems).

These interventions will be conducted using authentic materials and skills for repairing and retrofitting heritage buildings and involves necessary modernization measures which go beyond purely preservation-oriented repair work.

Figure 9: Old town of Yao Chang Gu Zhai. Former residence of Zhang Chao

Figure 10: Old town of Yao Chang Gu Zhai. Vernacular buildings

Figure 11: Old town of Yao Chang Gu Zhai. Citywall ruins

The new constructions will be built in harmony with the local building culture and settlement layouts, especially when building new houses within or near existing historical or vernacular settlements.
The most innovative element of this development project is represented by the community participation: the effective protection of cultural heritage can be achieved only through wide community participation in recovery and reconstruction planning (Figures 12, 13).
This participatory planning should focus both on cultural importance and on the cultural and livelihood activities that depend on the conservation of these properties.

Figure 12: Old town of Yao Chang Gu Zhai. Masterplan

3. Conclusion

Vernacular housing and building practices often offer an affordable, environmentally sustainable, aesthetic and culturally appropriate response to people's sheltering needs.
On these basis, Chinese government has come to the conclusion that the preservation and the sustainable development of the rural villages is one of the key challenges facing China's future.
A plenty of traditional Chinese villages are entitled to receive considerable government support through the implementation of new pro-conservation policies and financial funding from the central government.
We cannot lose the art of building with earth especially in countries where it is still practiced and for this reason most of development programs involve the inhabitants in the making of their habitat and in the protection of their soul. This practice is carried not only because the local people still have an empirical understanding but also because in this way inhabitants are also in capacity to maintain, develop and make more beautiful their habitat. If traditional craftspeople are given a significant role in restoration activities, conserving cultural heritage can also help restoring local livelihoods.

Figure 13: Old town of Yao Chang Gu Zhai. Renders of the projects

References

1. A.VV., *5th international congress International Association of Engineering Geology*, volume 4: Proceedings / Comptes-rendus, Buenos Aires, 20-25 October 1986, Taylor & Francis, 1990.
2. Agnew, Neville, ed. 1997. Conservation of Ancient Sites on the Silk Road, *Proceedings of an International Conference on the Conservation of Grotto Sites*, Los Angeles, CA: *The Getty Conservation Institute*.
3. Agnew, Neville, ed. 2010. Conservation of Ancient Sites on the Silk Road, *Proceedings of the Second International Conference on the Conservation of Grotto Sites, Mogao Grottoes*, Dunhuang, People's Republic of China, June 28-July 3, 2004. Los Angeles, CA, *The Getty Conservation Institute*.
4. Council of Europe, *Council of Europe Framework Convention on the Value of Cultural Heritage for Society*, Faro, 27.X.2005;
5. Frenda A., The agri-cultural heritage system of yáodòng settlement in the Loess Plateau (PRC). A dynamic conservation approach for a sustainable landscape development and planning, in *Proceedings of International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES15*, Beirut-Lebanon, April 17-20, 2015.
6. Frey P., Learning from Vernacular: pour une nouvelle architecture vernaculaire, Actes Sud, Arles, (2010).
7. Golany G., Chinese earth-sheltered dwellings: indigenous lessons for modern urban design, University of Hawaii Press, Honolulu, 1992.
8. Hou Jiyao, Master Jia Weitung, The Protection and Development of Rammed Earth and Adobe Architecture in China, in *International Council on Monuments and Sites. U.S. Committee, and Getty Conservation Institute. 1990. 6th*

International Conference on the Conservation of Earthen Architecture Adobe 90 Preprints: Las Cruces, New Mexico, U.S.A., October 14-19, 1990. Los Angeles, CA, *The Getty Conservation Institute*, p. 72-76.
9. ICOMOS, Québec declaration on the preservation of the spirit of place, adopted at Québec, Canada, October 4th 2008.
10. Johnson I., China's Great Uprooting: Moving 250 Million Into Cities, *New York Times*, June 15, 2013.
11. Johnson I., Pitfalls Abound in China's Push From Farm to City, *New York Times*, July 13, 2013.
12. Luo Deyin, 2013 Annual Report on the Conservation and Development of Traditional Villages, in *TCVB. Traditional Chinese Villages Bulletin*, Inaugural issue 01, January, 2015, p. 9-12.
13. UNESCO's LEAP (Local Effort And Preservation) program in Asia-Pacific region: http://www.unesco.org/webworld/netaid/clt/leap_apa.html.
14. UNESCO's World Heritage List, Chinese properties: http://whc.unesco.org/en/statesparties/cn.
15. UNESCO, Silk Roads: the Routes Network of Chang'an-Tianshan Corridor, http://whc.unesco.org/en/list/1442/
16. UNESCO, Chinese Section of the Silk Road: Land routes in Henan Province, Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, and Xinjiang Uygur Autonomous Region; Sea Routes in Ningbo City, Zhejiang Province and Quanzhou City, Fujian Province - from Western-Han Dynasty to Qing Dynasty, http://whc.unesco.org/en/tentativelists/5335/ .
16. Chinese Historic and Cultural Cities and Villages (中国历史文化名村 "Zhōngguó lìshǐ wénhuà míng cūn"): http://zh.wikipedia.org/wiki/%E4%B8%AD%E5%9B%BD%E5%8E%86%E5%8F%B2%E6%96%87%E5%8C%96%E5%90%8D%E6%9D%91 .
17. Ordinance for the protection of the historical and cultural towns and villages (历史文化名城名镇名村保护条例 "Lìshǐ wénhuà míngchéng míng zhèn míng cūn bǎohù tiáolì"): http://www.unesco.org/culture/natlaws/media/pdf/china/china_regprotectionhiscities_corof.
18. The New Generation of Yaodong Cave Dwellings, Loess Plateau: http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=314